A liquid helium circulation system for biomagnetometers

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1 Introduction

Though the use of MEG is steadily increasing, there are two ineligible problems to prevent widespread use of MEG; that are the extravagant waste of the expensive liquid helium into the air and the need to transfer liquid helium into a dewar frequently. However there have been few reports that had dealt with this problem.

One research was aimed to develop direct cooling system that requires no helium. However, the produced noise from the cooling system seems to prevent normal experiments in the system [1]. So the second feasible way is to collect the evaporated gas and cool it down with a small cryocooler. There are several commercially available such systems for the study of low temperature materials (TRG-350D, Taiyo Toyo Sanso Co., Ltd.; HRT-K212, Sumitomo Heavy Industries, Ltd.). However those systems have a common problem that they require huge electric energy to make liquid helium and they produce big magnetic noise. Hence, we are developing other type of helium circulation system that has no such problems and usable for MEG systems.

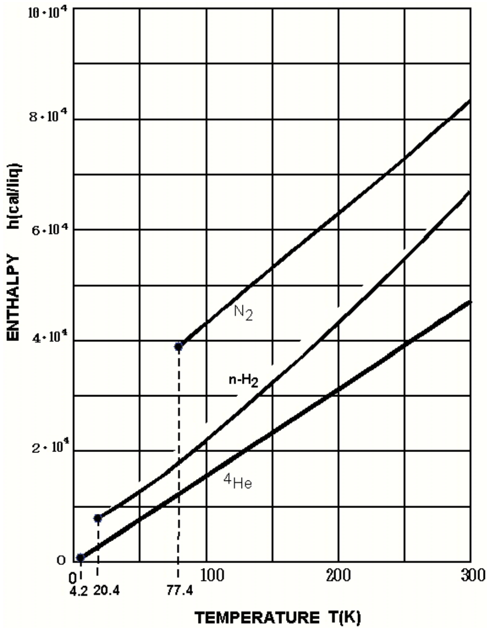

Figure 1: *Characteristics of low temperature helium.*

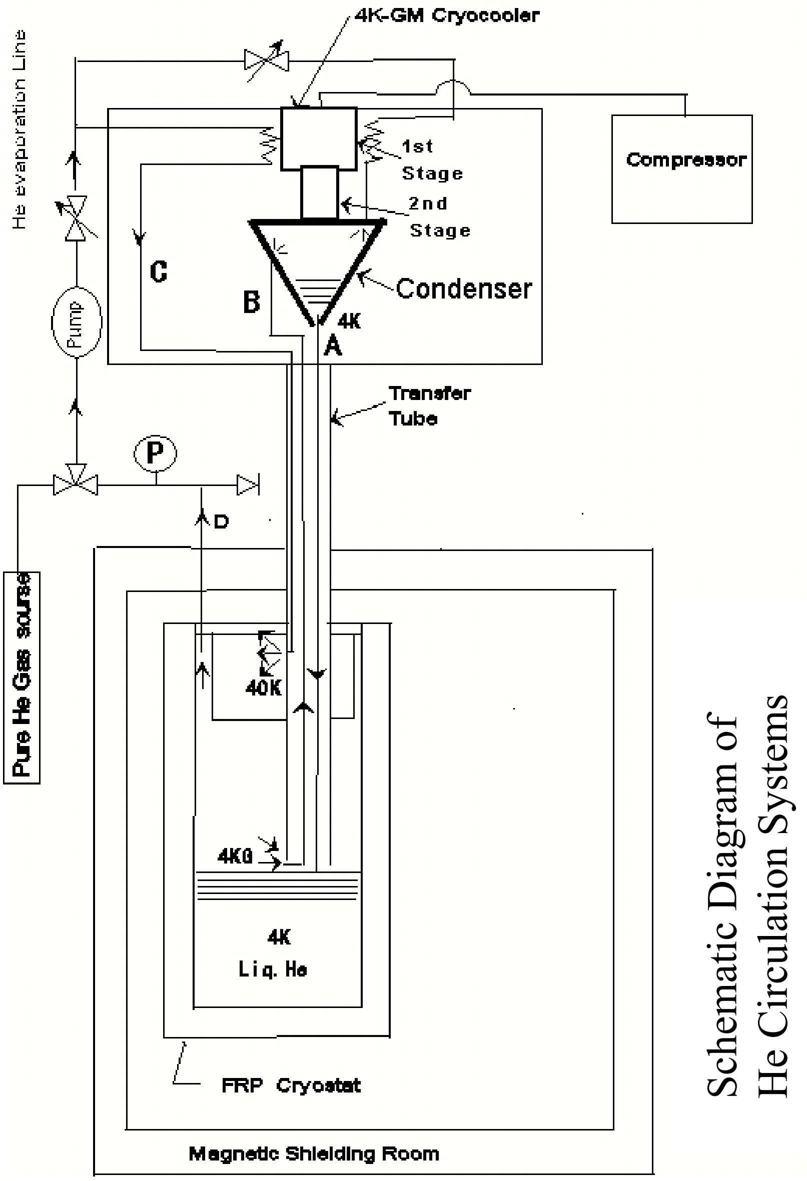

Figure 2: *A helium circulation system, which is designed to eliminate liquid helium transfer and waste of helium. It dose not require so much electricity as those developed for material study.*

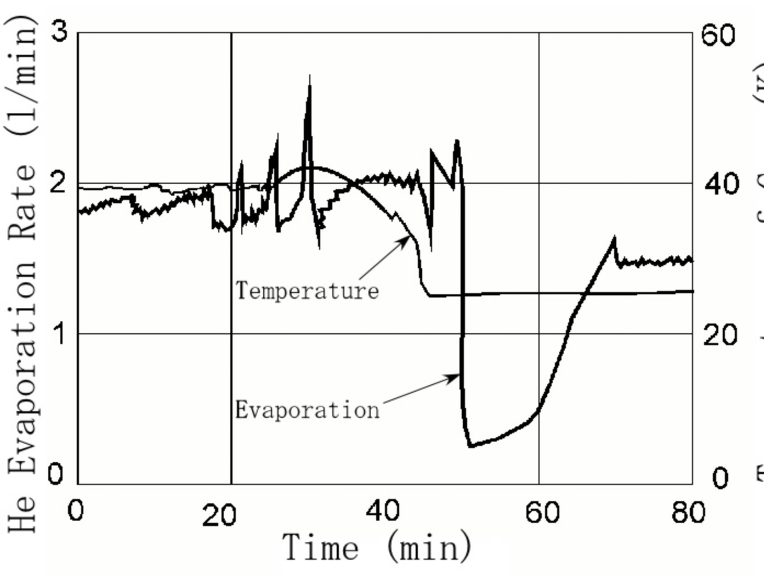

Figure 3: *A typical data showing condeser of helium gas in the dewar.*

2 Methods

The basic idea is to use an intermediate temperature helium gas to cool the dewar instead of using lower temperature evaporated helium gas. At present, all the systems are using all the evaporated helium gas to cool the dewars.

Fig. 1 depicts enthalpy of He, H_2 and N_2. The most noteworthy features of He are its small evaporation heat and comparable specific heat with H_2 and N_2. That means we need relatively large amount of He to keep the materials at helium temperature and also can use helium gas to cools down efficiently. However the produced heat from SQUIDs per se is very small and most cooling capacity is used to take out the heat coming from outside the dewars. Hence, we can use relatively higher temperature helium gas to cool the dewar like gas cooling system using nitrogen for MRI.

On the other hand, most small cryocoolers have 2 or 3 cooling stages. The higher temperature stages have relatively large cooling capabilities and the lowest temperature stage has smaller cooling capability and requires huge electric energy. Consequently, if we use the helium gas produced by higher temperature stage to take out the heat coming from outside the dewar and use liquid helium just to keep the SQUIDs at helium temperature, the efficiency of energy would be improved remarkably.

3 Results

Fig. 2 shows the schematic diagram of the developing system in line with the above idea. Evaporated helium gas is gathered immediately through pipe B and cooled down in a condenser by the second stage of a cryocooler and returned to the surface of liquid helium in the dewar through pipe A. The intermediate temperature helium gas, say at 40K, flowed into the dewar through pipe C at a higher position just below a neck tube. The evaporated gas through the neck tube takes out the heat invading from outside the dewar and is circulated to the first stage of the cryocooler. There is another line to increase the amount of liquid helium that lead the evaporated helium gas to the first and second staged. It is depicted at upper left and a valve controls the amount. Also the amount of circulation of intermediate temperature gas is controlled by a small pump and a valve shown in the left.

Fig. 3 depicts a typical data that shows circulation of low temperature helium gas. Thick line is evaporation rate from the dewar and thin line is temperature at the bottom of the neck tube. The liquefaction and absorption of the evaporated helium gas started at about 10 min. and pour of 40K gas started at about 30 min. It resulted steep increase of outflow of the evaporated gas and increase of the temperature at the bottom of neck tube. The assessment of the system is now ongoing.

Acknowledgements

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References

1. Suzuki, A. *et. al.* : Reliability of AEF recordings using a cryocooled 61-channel MEG system in normal adults, *The Journal of Japan Biomagnetism and Bioelectromagnetics Society*, **11**-1, 168-169, 1998 (in Japanese)